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Principal Investigator: Marvin Chodorow (10)

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409 640

1. Electronic Scanning and Focusing of Acoustic Beams

On this program we demonstrated new types of electronically scanned and focused acoustic imaging systems. As part of the program, we arrived at a new design philosophy and developed technology for construction of acoustic transducer arrays. Because of this initial effort, Stanford now has the largest program in Nondestructive Testing of any university in the country. We are now being supported by block funding from AFOSR to continue our work in this field on a long-term basis.

Our transducer design techniques are being employed commercially by Precision Acoustic Devices, Inc., a commercial firm started by the two students involved with the work. Varian Associates are now building an acoustic imaging system, with ARPA support for use in NDT. This work is closely associated with the design philosophy and with the methods pioneered in this laboratory, where we demonstrated for the first time the power of acoustic imaging methods for the Nondestructive Testing application.

2. Surface Acoustic Wave Convolution and Signal Storage

This work is an important extension of the acoustic surface wave convolver first demonstrated in this laboratory, in which a reference signal can be stored in a silicon element in a surface acoustic wave convolver, and later read out, correlated or convolved in real time with an arbitrary input signal, with potential for storage times in the tens of milliseconds.

Convolvers based on the design method and much of the technology pioneered at Stanford are now being built by Texas Instruments, Lincoln Laboratories, France, Britain, and other countries for use in military radar systems. They have been shown to have important applications in spread spectrum communications.

The storage correlator has been shown by us to be a very useful adaptive filter. Both here and at Lincoln Labs, correlation of codes with time-bandwidth products of approximately 30,000 has been demonstrated, with a predicted ultimate capability of up to 10^6. Demonstrations have been made by us of the use of a monolithic storage correlator to decrease the amplitude of an interfering cw signal by 30 dB, and to correlate long PN codes. These are important applications for use in spread spectrum systems.

The work is leading to a new class of devices employing silicon technology and combining the best features of CCDs and other types of transversal filters with ASW concepts.

3. Scanning Acoustic Microscope

This is a new device for microscopic imaging based on acoustic radiation at 3 GHz. The wavelength of sound in water at this frequency is equal to optical wavelengths. The resolution of the acoustic microscope at the present time is comparable with the optical microscope. It has been used for viewing a wide variety of integrated circuits. It holds an advantage over the optical instrument in that it can be used to collect information

in depth — details of structure that lies beneath the surface and within the layers that are commonly used in the fabrication of integrated circuits.

The characteristics of this new instrument have been carefully reviewed by technical staff members at IBM, TI, Intel, Bell Labs, Varian Associates and Hewlett-Packard. Each of these organizations has provided us with samples and they have spent time in analyzing the acoustic micrographs. At least one of these has commenced a project to build their own acoustic microscope so as to gain a detailed understanding of its operation in their own laboratories.

4. Surface Acoustic Wave Amplifiers

The first surface acoustic wave amplifiers with high terminal gain were demonstrated on this program, and this was followed by models capable of cw operation and monolithic models using thin film semiconductor elements, and these have potential for increasing the signal to noise ratio and dynamic range in future surface acoustic wave devices involving long time delays. The work has been followed up at Lincoln Laboratories, in Japan, and in France, who have demonstrated low noise devices operating on a cw basis.

5. Electrical Behavior of Superconducting Quantum Devices using High Transition Temperature Materials

We have made substantial progress in solving the materials problems involved in fabricating thin film superconducting devices from the high transition temperature superconductors. This has led to oxide layer tunnel junctions of potential technological significance and promising SNS micro-bridge Josephson junction structures. We have also developed a new, refractory lift-off process suitable for fabricating microcircuits of these materials for which, because of the high deposition temperatures required, conventional photoresist is unusable. These accomplishments are essential steps toward practical application of such high transition temperatures with their generally superior superconducting properties and potential for use with small closed-cycle cryogenics refrigerators.

6. Optical Scanning Using Surface Acoustic Waves

A new device was demonstrated in which a surface acoustic wave provides electronic scanning of an optical image projected onto a silicon surface, giving directly either a reproduction of the imaging or the Fourier transform or other transform of the image in real time.

Texas Instruments has been carrying out a study contract for ARPA on infrared imaging using these techniques. This work looks extremely promising, and it is expected that test devices based on these principles will be constructed during the next two years.

Work in France, carried out by one of our former students, has shown that these devices can exhibit extremely high sensitivity.

7. Surface Acoustic Wave Long Delay Lines

No additional report.

8. Acoustic Transducers using Piezoelectric Polymers

The first practical ultrasonic transducers have been demonstrated using a new piezoelectric plastic film material (polyvinylidene fluoride), which have much larger bandwidth, much better impulse response, much better acoustic matching into water, and higher upper operating frequencies than commercial PZT transducers, as well as mechanical advantages. These results were instrumental in the establishment of an interdisciplinary research program at Stanford under NSF, AFOSR and ONR support, studying new approaches to synthesis of the polymer, fabrication of thin films, and experimental demonstration of ultrasonic transducers and arrays for application to nondestructive testing and evaluation of materials and structures where high resolution is required, or where, curved surfaces or large areas are involved, or where inexpensive construction is important.

9. Measurement of Fast Physical Processes Using Picosecond Laser Pulses

A novel technique has been developed for measuring time constants of very fast physical processes, using a spatial volume grating pattern (hologram) produced by interfering optical picosecond pulses from mode-locked lasers. This technique has been successfully applied to the study of energy transport in molecular crystals in the picosecond time domain, namely diffusion of molecular exciton states in crystals (a,b), which is a problem of fundamental importance in organic chemistry, semiconductor physics and biophysics, since in these areas, exciton transport in the picosecond regime is believed to be of primary importance.

Due to the importance of these techniques, a twin laboratory setup exists now in the Chemistry Department at Stanford University for the sole purpose of detailed study of time resolved exciton processes.

Also a similar facility is being developed at the Physical Chemistry Department at the University of Gromingen, Holland, to study coherent and transport processes in organic solids.

In addition, a novel acoustooptic interaction was observed in molecular crystals, resulting in an amplitude grating like behavior. Optical and acoustic properties appear interleaved, and direct information on phonon processes in crystals is obtained in addition to the excited state transport information (c).

These studies also led to the development of photoacoustic microscopy as a viable powerful and important technique for studying materials and surfaces, in a method which concentrates the advantages of acoustic and optical microscopy in a single process (d).

An extension of the grating technique is currently being developed, which should allow subpicosecond resolutions without the need for picosecond lasers (e).

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No additional report.

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for Items 1, 2, 3, 5, 6 and 8, shown on attachment.

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ADDENDUM

Additional possibly relative information is included in the addendum below. This includes Item 1, important work done under current contract N00014-75-C-0632 on applications of a new tunable VUV light source, Items 2 and 3, significant work done within the last ten years under JSEP support on SEL contracts. A related bibliography addendum for Items 1, 2, and 3 is attached.

(1) Most recently, work under Joint Services support (N00014-75-C-0632) has been aimed at vacuum ultraviolet spectroscopy using the new anti-Stokes light source. This work has attracted significant attention and, with some luck, may become a useful VUV-soft x-ray spectroscopic technique.

(2) In 1971 the electronically tunable acousto-optic filter was used to construct the first electronically tunable dye laser. This device had a linewidth of several wavenumbers and was tunable over the visible spectrum. Although the device is not yet of commercial importance, it remains to date the only way to construct a rapidly tunable, randomly accessible, electronically tunable laser.

There were also important studies of the aperture-bandwidth characteristics of the acousto-optic filter. The acousto-optic filter could play a substantial role in DOD application.

(3) For several years there has been a program on up-conversion of infrared signals and images to the visible making use of the nonlinear optical metal vapor techniques developed in this group. Although the program has technically been very successful, it is not yet a part of on-going technology.

A list of relevant publications which resulted from Joint Services support, numbered according to the above listing, is attached.

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Polyvinylidene Fluoride Acoustic Transducers
Surface Acoustic Wave Convolution
Silicon Element Signal Storage
Surface Acoustic Wave Amplifiers
Superconducting Quantum Devices
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20. ABSTRACT (Continue on reverse side if necessary and identify by Block no.)

This report updates the information provided in the Fifteen Year Report (dated: September 1976), setting forth a number of the significant accomplishments under JSEP sponsorship in the E.L. Ginzton Laboratory (formerly the Microwave Laboratory) of Stanford University. The report summarizes, as well, the flow of some of this research from the JSEP Contract to other sponsored research contracts and grants within the university, and outside of the university- to other research and educational institutions, as well as industry.

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